

Measuring the Costs and Trade Effects of Phytosanitary Protocols: A U.S.–Japanese Apple Example

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This article investigates the trade impact of Japan's decision in 2005 to revise its phytosanitary protocol for fire blight for U.S. apple imports but retain its codling moth protocol. The analysis presents a participation model to measure the economic costs of phytosanitary barriers to trade. The model provides an explicit cost of the phytosanitary barriers in terms of the structure of the protocols, an important advantage over the price-wedge methodology. This makes it possible to separate the economic costs of various protocols—in this case, the fire blight and codling moth protocols.

In the past, phytosanitary protocols required by Japan for U.S. apple imports severely hampered U.S. growers' efforts to export to that market. These protocols primarily addressed fire blight, a bacterial plant disease, and codling moth. The United States long argued that the fire blight protocol was not based on science; specifically that mature, symptomless fruit does not carry the disease. In 1997, the United States requested, without success, that Japan modify its fire blight protocol. In 2002, the United States was granted a panel by the World Trade Organization (WTO) to hear its case against the Japanese fire blight protocol. Years of legal wrangling, with the WTO repeatedly siding with the U.S. position, delayed the resolution of the case. In August 2005, Japan issued a new, less restrictive fire blight protocol for apple imports from the United States that complied with the WTO ruling that the original fire blight protocol was not justified and was in breach of Japan's WTO commitments (Calvin and Krissoff, 2005). The United

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States has not disputed the consistency of the Japanese codling moth protocol with WTO principles.

With the elimination of the most costly features of the fire blight protocol, U.S. apple growers have an opportunity to ship apples to a high-quality export market at a lower cost. Growers must still, however, comply with the codling moth protocol to control this pest. This article investigates how trade to Japan could change with the reduction in phytosanitary barriers facing U.S. apples. There is no simple quantitative measure of the value of a phytosanitary barrier. The price-wedge model is one of the primary methodologies used to measure the cost of phytosanitary barriers (Beghin and Bureau). The methodology compares prices in two countries to obtain a price wedge; subtracts the value of the tariff, transportation, and transaction costs to move a product from one market to another; and assigns the residual to the cost of compliance with phytosanitary barriers and the additional tariff associated with that cost. While simple conceptually, data problems make applications difficult. Criticism of the price-wedge model focuses on two points. First, the traditional price-wedge methodology assumes that the two goods compared are perfect substitutes, which may often be unrealistic. The second criticism is that the cost of the phytosanitary barrier is measured as a residual and not as an explicit function of the structure of the protocols. The inability to consider parts of the phytosanitary barrier separately is an important drawback.

Several studies have used the price-wedge model to address the cost of the Japanese phytosanitary barriers for U.S. apples. Calvin and Krissoff (1998) first analyzed the apple case, assuming perfect substitution and looking at the removal of all phytosanitary barriers. Yue, Beghin, and Jensen extended the basic price-wedge methodology by generalizing to the case where goods are not perfect substitutes. When products are perfect substitutes, the model collapses to the standard price-wedge model. Their analysis is limited to the case where all phytosanitary protocols are removed. Calvin and Krissoff (2005), working with the price-wedge methodology and the perfect substitution assumption, used an ad hoc method to estimate the costs of the fire blight and codling moth protocols separately.

To formally address the problem of how to develop separate costs for the fire blight and codling moth protocols, this analysis turns to another strand of the literature, which advocates measuring the actual cost of phytosanitary barriers (Beghin and Bureau; Peterson and Orden). In addition, Maskus, Otsuki, and Wilson noted that uncertainty complicates measurement. Building on that literature, we develop a simple participation model that directly links the cost of the phytosanitary barriers to the requirements of the protocols and illustrates the U.S. grower's decision about whether to participate in the Japanese export program. The structure of the protocols introduces significant uncertainty as to the outcome of participation in the program, which increases the *economic* cost of participating in the export program beyond the *accounting* cost. The economic cost is represented by the expected price differential between the domestic and export market that the grower needs to compensate for compliance with the uncertain export protocol. This approach was motivated by the need to separate the costs of the phytosanitary barriers to concentrate on the impact of removing just the fire blight protocol. The realization that the accounting cost of the Japanese apple phytosanitary barriers was smaller than the economic cost as measured by a price wedge

also provided impetus. To concentrate on our objective and simplify the analysis, we make the strong assumption of perfect substitution.

This article begins with a discussion of standard U.S. apple export procedures and the Japanese export protocols for fire blight, past and present, and codling moth. Then the article turns to a description of the participation and trade models. The participation model provides estimates of the economic cost of the Japanese phytosanitary protocols for U.S. apples in place through the 2004/05 season. While fire blight has been the focus of the trade dispute, the analysis shows the importance of the remaining codling moth protocol as a deterrent to trade. An alternative protocol that would control codling moth with less damage to apples could boost trade opportunities. The estimate of the economic costs of the phytosanitary barriers provides the basis for examining the trade effects of eliminating just the fire blight protocol and then eliminating both protocols together. The analysis uses a static, partial-equilibrium trade model to estimate the change in Japanese Fuji apple imports. Empirical results of the participation and trade models follow. Trade impacts of removing the fire blight protocol are substantial but results depend crucially on the value of model parameters.

Standard U.S. Apple Export Procedures and Japan's Phytosanitary Protocols

The United States is a major apple exporter. Many markets accept U.S. apples produced under standard industry operating practices with the addition of a phytosanitary certificate asserting that the packed apples have been inspected and are free of diseases or pests of concern. The Japanese phytosanitary protocols for U.S. apples, which were in operation for the 1994/95–2004/05 seasons, had two main parts—preharvest activities for detecting fire blight, and postharvest activities for killing codling moth—that were not part of the U.S. standard industry operating practices. The cost of these protocols was so high that there were no U.S. shipments to Japan during the 2004/05 season (see Calvin and Krissoff [2005] for the history of U.S.-Japanese apple trade).

With the original Japanese fire blight protocol, growers had to register their acreage for the program in early spring. Each registered parcel consisted of core and buffer (500 meters on all sides of the core) areas. Representatives of the U.S. Department of Agriculture inspected each tree in the core area and any natural fire blight hosts in the buffer zone three times for signs of fire blight—at blossom time, when the fruit was 3 cm in size, and just prior to harvest in the presence of a Japanese inspector. Any evidence of fire blight found in the core or buffer zone eliminated the orchard from the export program for that year. In 1994/95, the first season of the export protocol, about half of the core acres were disqualified by harvest time. If there was no evidence of fire blight at the final orchard inspection before harvest, apples from the core acres were eligible to continue in the export program. Buffer zone apples could never be exported to Japan regardless of fire blight status. The new protocol eliminates orchard registration, buffer zones, and orchard inspection. The old protocol included inspection of packed apples and a modified inspection remains in force (Office of the U.S. Trade Representative).

At harvest, growers had to decide whether to proceed with the postharvest protocol. If apples were free of fire blight but a high percentage of the apples

were not appropriate for the Japanese market, the grower might decide to quit the program before incurring more costs. Japanese consumers are used to large and very good-looking apples. Growers made decisions regarding participation in the spring before relative market conditions in the United States and Japan were known for the upcoming marketing season. Growers could comply with every phytosanitary requirement only to discover that market conditions after harvest precluded trade. Japan is a major apple producer and would not necessarily import large volumes every year if its domestic supplies were ample. At harvest time, there might be enough information for a grower to decide there were no trade opportunities and redirect the apples to the domestic market.

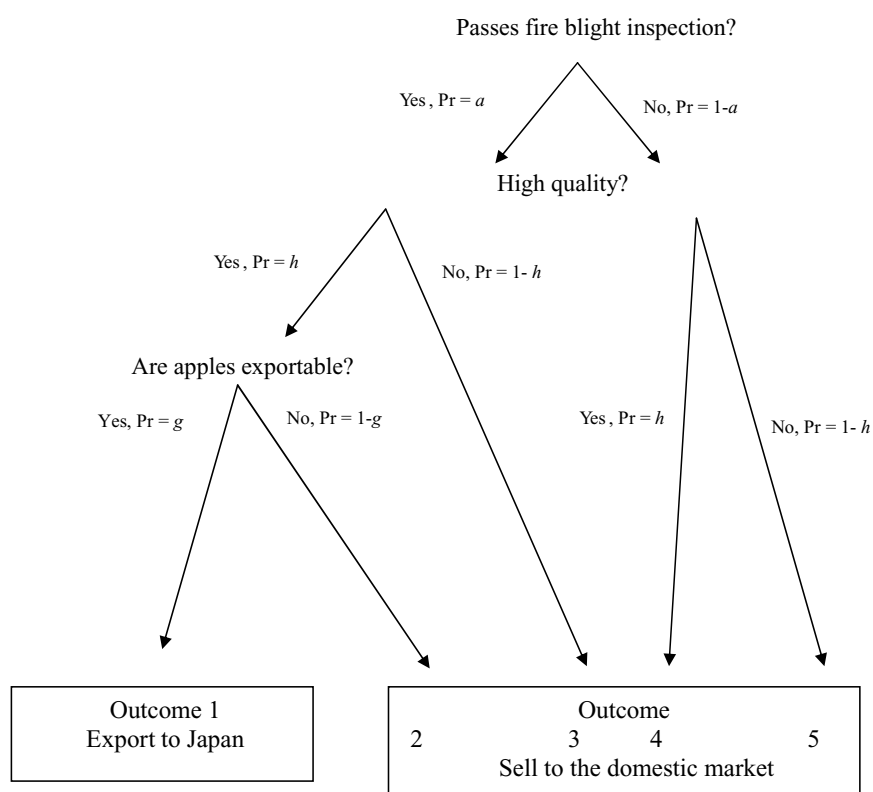
The postharvest treatment, which remains in effect, is mostly directed at codling moth and its larva; apples are held in cold storage rooms for fifty-five days and then they are fumigated with methyl bromide. Only the best-quality apples can withstand the stress of fumigation, which can reduce the quality of the apples to the point, where some may not be marketable. After fumigation is complete, growers could still decide not to export if relative market prices are unfavorable.

Participation and Trade Models

Assume that a U.S. apple grower faces two alternatives—participating in the Japanese export program with the chance of exporting to Japan or producing for the domestic market and other international markets. For simplicity, consider the second approach the “domestic” alternative, since export markets other than Japan can be supplied from apples produced to U.S. standards. Also assume a risk-neutral grower, who requires that the expected net revenue of participating in the Japanese export program exceeds the expected net revenue of just producing for the domestic market.

For the risk-neutral grower who decides to only grow for the domestic market, the expected net revenue per pound of production, R_D , depends on domestic prices, the quality of apples that are produced, and production costs. Let the grower produce two types of apples: high-quality apples and low-quality apples. High-quality apples can be sold in both the U.S. market and the Japanese market if there were no phytosanitary barriers. Low-quality apples are those that are not acceptable to the Japanese consumer and can only be sold in the domestic market. Assume the distribution of quality is exogenous. Expected net revenue per pound of apples produced for the domestic market is: $R_D = hP_H + (1 - h)P_L - C$, where h is the probability of producing high-quality apples, P_H is the expected price in the domestic market for a pound of high-quality apples, P_L is the expected price in the domestic market for a pound of low-quality apples, and C is the production cost per pound of apples.

For the U.S. grower who participates in the Japanese export program the expected net revenue (R_J) is more complicated due to the structure of the phytosanitary protocols. There are five possible outcomes if a grower participates but only one actually involves exporting to Japan. In four cases, a grower can incur some or all of the costs of the program but not be able to export. To determine R_J , the grower must consider the five possible outcomes and the probability of each (figure 1). This is done before the season begins. First, the grower must assess the probability of passing the fire blight inspections, a —the probability of no fire

Figure 1. Scenario tree for a grower participating in the Japanese export program

blight occurring in the core and buffer areas. Second, the grower must consider the probability that apples grown in core acres will be of the high quality required by Japanese consumers, h . Third, in the early spring the grower must estimate the probability of favorable market conditions for export to Japan in the following winter and spring, g .

In outcome 1, everything works in favor of the grower who wants to export to Japan—there is no fire blight, all apples are high-quality apples, and all apples are exportable to Japan (i.e., relative prices support trade). Outcome 1 is achieved with probability ahg . Assume the grower sells apples in the core to the shipper for P_E , the expected price per pound that a grower would receive from a shipper in the United States for a Japan-exportable apple. P_E is the maximum of P_H and P_J , the price the grower would receive from the shipper if the apples were sold to Japan. When $P_E = P_J$, apples in the core are sold to Japan, otherwise the apples would be diverted to the more profitable domestic market. Let b represent the proportion of core area apples to total apples produced in the core and buffer areas. Due to methyl bromide fumigation damage, the grower expects to receive a discounted price of dP_E per pound of fumigated apples where d represents the share of the expected price the grower would receive. High-quality apples from the buffer zone are

sold in the domestic market at P_H . The grower incurs the same basic production costs as if producing for the domestic market, C , with the additional costs of fire blight inspections, C_{FB} , and the cost of methyl bromide and other postharvest costs, C_{MBO} . Growers participating in the export program always incur the fire blight costs. Growers only incur the cost of methyl bromide fumigation and other postharvest expenses on the apples from their core area if they do not have fire blight, their apples are high quality, and the Japanese market has favorable prices. Expected net revenue is: $ahg\{[bdP_E + (1 - b)P_H] - [C + C_{FB} + bC_{MBO}]\}$.

Outcome 2 is the case where the grower has no fire blight and has high-quality apples but the Japanese price at harvest time is not sufficiently high to warrant exporting U.S. apples ($P_E = P_H$). In outcome 3 there is no fire blight but apples are not high quality. In outcomes 4 and 5, there is fire blight so the grower cannot export to Japan regardless of the quality of the apples. In outcomes 2–5, after paying the fire blight inspection costs, the grower sells the apples in the core and buffer area to the domestic market and does not incur any postharvest treatment costs. See the Appendix for the complete derivation of R_j .

To participate in the Japanese export program, the expected net revenue of participating must at least equal the expected net revenue of producing for the domestic market,

$$(1) \quad R_j - R_D = ahgb[dP_E - P_H] - [C_{FB} + ahgbC_{MBO}] \geq 0.$$

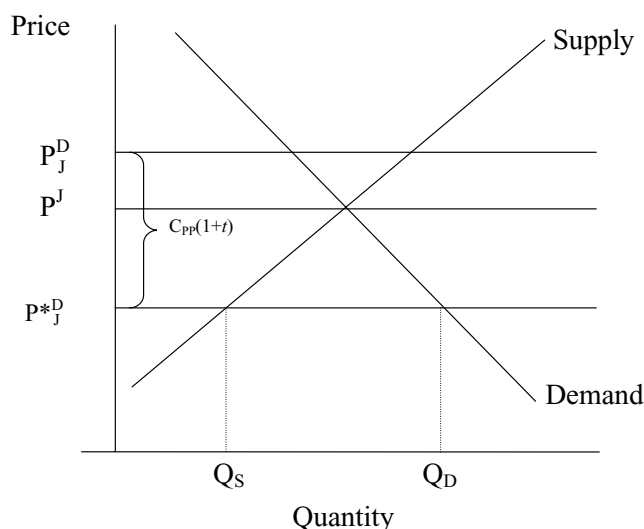
The risk-neutral grower would only participate in the Japanese export program if the expected price of an exportable apple exceeds the expected price of a high-quality apple for the domestic market plus the additional expected economic costs of the Japanese phytosanitary program for fire blight and codling moth, adjusted for the probability of exporting to the Japanese market at less than the full expected price:

$$(2) \quad P_E \geq \left[\frac{1}{d} \right] \left(P_H + \frac{1}{ahgb} C_{FB} + C_{MBO} \right) = A(P_H + B C_{FB} + C_{MBO}),$$

where $A = [\frac{1}{d}]$ and $B = [\frac{1}{ahgb}]$.

If there were no uncertainty, A and B would both equal 1 and the grower would only require that the export price exceeds the domestic high-quality price plus the accounting costs of the fire blight and methyl bromide and other postharvest treatments. But with uncertainty, the apples that do reach Japan, selling at the discounted price, must cover the costs invested in those that are not exported, including those in the buffer zone. Each additional source of uncertainty increases the economic cost of the export program. The cost of the fire blight protocol increases by B —the inverse of the probability of exporting—to compensate for the low probability of exporting. The postharvest costs are divided into two parts. The direct postharvest costs, C_{MBO} , are only incurred if there are exports so there is no chance of paying for the procedure and then not being able to export.¹ The term A reflects the compensation required to cover any losses due to methyl bromide fumigation. This indirect impact of methyl bromide affects each component of the export price, including the cost of the fire blight protocol. Subtracting P_H from P_E yields the total economic cost of the phytosanitary protocol:

Figure 2. Measuring the cost of the phytosanitary protocols in the Japanese apple market



$$C_{PP} = P_E - P_H = BC_{FB} + C_{MBO} + (A - 1)(P_H + BC_{FB} + C_{MBO}).$$

Delivering a U.S. export-quality apple to Japan is costly. The minimum price required to entice risk-neutral U.S. growers and shippers to participate in the program and deliver apples to the Japanese market, P_J^D , equals:

$$(3) \quad P_J^D = (P_E + k)(1 + t) = (P_H + C_{PP} + k)(1 + t),$$

where k represents transaction costs and t represents the Japanese ad valorem tariff rate (figure 2). The grower in the United States receives a price of P_E , shippers and intermediaries receive k , and the Japanese government collects the tariff revenue. If there were no phytosanitary barriers, P_J^D would equal P_J^{*D} , the minimum price of a high-quality apple produced under standard industry operating practices and delivered to Japan. If P_J^D is greater than or equals the observed market price for a comparable apple in Japan, P^J , then trade is not profitable. Therefore:

$$(4) \quad \begin{aligned} &\text{if } P_J^D < P^J, \text{ then } T = D(P_J^D) - S(P_J^D), \\ &\text{otherwise, } T = 0, \end{aligned}$$

where T is Japanese imports, D is Japanese consumer demand and S is Japanese domestic supply. In this model, trade reflects total Japanese imports from any source, not necessarily just from the United States.

Consider the case where the Japanese phytosanitary protocols are removed and the U.S. standard industry operating practices are accepted by Japan as an adequate protection against the disease. The change in Japanese imports of apples can be determined by differentiating equations (3) and (4):

$$(5) \quad dT = \varepsilon_d D \left(\frac{(1+t)dC_{PP}}{P_J^D} \right) - \varepsilon_s S \left(\frac{(1+t)dC_{PP}}{P_J^D} \right),$$

where ε_d and ε_s are Japanese price elasticities of demand and supply and $(1+t)dC_{PP}$ is the change in the P_J^D with changes in the protocols.² This model can address changes in either protocol separately or together. For the trade model, $(1+t)dC_{PP}$ must be truncated to that portion that has an impact on trade. Clearly, reducing the value of the barrier from P_J^D to P^J in figure 2 has no impact on trade; only a change in phytosanitary barriers that reduces P_J^D below P^J will have an impact.

An Empirical Analysis

For the empirical analysis, we estimate C_{PP} based on the protocol in place during the 1998/99–2003/04 seasons and then estimate what trade would have been in the same seasons without the fire blight protocol. While the new fire blight protocol has a few provisions, we assume the cost is zero. The analysis is limited to Fuji apples, which are grown in both countries and account for about 55% of Japanese apple production. The models require data on comparable prices in the two markets, transaction costs, the tariff, costs of the protocols, the probability of each outcome, and parameters of the Japanese apple market such as the elasticity of demand (the Appendix provides additional details).

With no common grading system, it is not possible to directly compare identical U.S. and Japanese apples. But by carefully selecting a particular type of U.S. apple to compare, we minimize any potential quality difference.³ The model uses price data for very large and high-quality U.S. Fuji and average Japanese Fuji apples. The average annual fob price for high-quality U.S. apples, produced with standard industry operating practices, is 50 cents per pound and the Japanese wholesale market price is 108 cents (table 1). Japan produces two types of Fuji apples—bagged Fuji and sun Fuji. While bagged Fuji, grown with a protective bag around each piece of fruit, are very high-quality and expensive apples, sun Fuji apples are grown without the bag and exposed to the sun, similar to U.S. production practices, and sell at lower prices. Currently, sun Fuji apples account for an estimated 70% of apples in the Japanese wholesale markets (U.S. Embassy in Japan, 2004).

Parameters defining the phytosanitary protocols are based on industry experience in the 1994/95 season, the period in which the United States exported the largest volume of apples to Japan, and estimates from apple experts (Archer, 2004). The share of core acres to core plus buffer acres, b , equals 0.33 with the probability of core and buffer acres passing the fire blight inspection, a , equal to 0.50. The share of Fuji apples expected to meet Japanese consumer standards, h , is set at 0.20. U.S. growers only send their very best apples to Japan and Fuji is a relatively difficult apple to grow in Washington so not all production would have the size and color characteristics that Japanese consumers prefer. The probability that postharvest Japanese prices are sufficiently higher than U.S. prices to merit export, g , equals 0.67. A review of the 1998/99–2003/04 seasons indicates that in four out of six years there would have been export opportunities based on the

Table 1. Average prices and costs for U.S. growers exporting apples to Japan

Item	Economic Costs
	<i>cents per pound</i>
U.S. grower's price (P_H)	50
Transaction costs (k)	33
Phytosanitary costs (C_{PP})	15
Fire blight (BC_{FB})	7
Methyl bromide fumigation and other costs (C_{MBO})	3
Price discount due to methyl bromide $((A-1)(P_H+BC_{FB}+C_{MBO}))^1$	5
Tariff	13
Tariff on P_H	9
Tariff on k^2	2
Tariff on C_{PP}	2
U.S. delivered price (P_J^D)	111
Japanese price (P_J)	108

1. If the fire blight protocol is removed, the total value of the methyl bromide price discount falls 1 cent to 4 cents per pound.

2. The tariff is only applied to that part of k accounted for the landed cost of a high-quality U.S. apple.

n.a. = not applicable.

Source : Economic Research Service, U.S. Department of Agriculture.

relative prices in the two markets. Finally, d , the share of the expected price received for damaged apples, is equal to 0.925.

The estimate of the economic costs of the phytosanitary protocols, C_{PP} , starts with the accounting costs of the protocols during the 1994/95 season—5 cents per pound. These are the *ex post* costs—observed accounting costs after the season divided by pounds of apples exported. But the participation model depends on *ex ante* economic costs—expected costs per pound of apples produced—which are 15 cents per pound: 7 cents per pound for the fire blight protocol, BC_{FB} ; 3 cents per pound for the direct cost of fumigation, C_{MBO} ; and 5 cents per pound for the price discount due to fumigation (table 1; see the Appendix for derivation of *ex ante* economic costs). The phytosanitary protocol adds 17 cents per pound to P_J^D (15 cents for the protocol and 2 cents for the tariff).

Adding transactions costs, economic costs for the fire blight and codling moth protocols, and the tariff (17%) to the Washington fob apple price yields the price of a Washington state apple delivered to the Japanese wholesale market, P_J^D , of 111 cents per pound, 3 cents above the expected Japanese price of 108 cents per pound. There is no economic incentive to participate. For a risk-averse grower, the economic cost of the protocol would be even larger.

For the parameters a , h , g , and b , a 5% increase in any one of them reduces C_{PP} by 2% and a 5% decrease raises C_{PP} by 3%. The most sensitive parameter is d ; a 5% increase reduces C_{PP} by 21% and a 5% decrease raises it by 23%. Clearly, improving the precision of d is important. Trade opportunities ($P_J-P_J^D$) under the baseline scenario are negative and a 5% change in any of these parameters

Table 2. Sensitivity analysis: Trade opportunities ($P_J - P_J^D$) in cents per pound

d	h				
	0.100	0.150	0.200	0.240	0.300
With fire blight and codling moth protocols ¹					
0.800	-26	-19	-16	-14	-12
0.850	-20	-14	-10	-9	-7
0.900	-15	-9	-6	-4	-3
0.925	-13	-7	-4	-2	-1
0.950	-10	-5	-2	0	1
1.000	-6	-1	2	3	5
Without fire blight protocol					
0.800	-5	-5	-5	-5	-5
0.850	-1	-1	-1	-1	-1
0.900	3	3	3	3	3
0.925	5	5	5	5	5
0.950	7	7	7	7	7
1.000	10	10	10	10	10

1. Baseline scenario is $h = 0.20$ and $d = 0.925$. Analysis is based on cents per pound while the prices in Table 1 are rounded to the nearest whole cent to simplify text discussion. Because of rounded prices, the price gap in Table 1 and in the text discussion is 3 but the actual price gap in the analysis is 3.68, rounded in this table to 4.

Source: Economic Research Service, U.S. Department of Agriculture.

would still yield negative or zero trade opportunities. Table 2 shows more detailed sensitivity analysis of the profitability of trade with respect to h and d . Let h range from 0.10 to 0.30 and d from 0.80 to 1. With both the fire blight and codling moth protocols in place, exporting to Japan is only profitable under the most optimistic conditions: if h is 0.30 and $d = 0.95$; or if h is at least 0.20 and there is no methyl bromide damage ($d = 1$). After removing the fire blight protocol, the cost of exporting declines for all combinations of d and h , but trade is only profitable for d of at least 0.90 and any level of h considered here.⁴ For d below 0.90, the codling moth protocol is still sufficient to make trade unprofitable.

For the trade model, U.S. Department of Agriculture attaché reports provide average supply, use, and trade data for Fuji apples in Japan (Foreign Agricultural Service). Japanese imports in recent years have been small or zero so the model assumes no imports when the phytosanitary barriers are in place. The analysis uses a Japanese demand elasticity estimate of -0.67 for Fuji apples (Kajikawa). In the absence of any known apple supply elasticities for the Japanese market, the model uses a long-run supply elasticity of 1 and a short-run elasticity of 0.1.

In the partial-equilibrium simulation model, the change in the market price due to a change in the phytosanitary barrier determines the change in Japanese

Table 3. Changes in Japanese apple imports with the removal of phytosanitary protocols

Eliminating protocol for:	Decline in C_{PP}	Decline in P_J^D	Decline in P_J	Change in Trade	
	Cents			Metric tons	\$ millions
Fire blight	8	9	6	27,639	31.3
Fire blight and codling moth	15	17	14	72,924	82.7

Source: Economic Research Service, U.S. Department of Agriculture.

imports. Removing the fire blight protocol reduces C_{PP} by 8 cents per pound (7 cents for the fire blight protocol and 1 cent for the impact on cost of damage from methyl bromide). P_J^D falls by 9 cents per pound and P_J by 6 cents (recall that the first 3 cents decline in P_J^D has no impact on P_J). This decline in market price leads to an estimated change in annual Japanese Fuji apple imports of 27,639 metric tons or \$31.3 million (table 3). Using a short-run supply elasticity of 0.1 would yield an increase of 12,670 metric tons. The trade increase estimates are total Japanese imports but we assume all the increase would accrue to the United States.⁵

If the methyl bromide protocol was not as expensive, removing the fire blight protocol would have had more of an impact since C_{PP} would not have been so severely truncated. For example, if the methyl bromide protocol was changed to increase the share of price received by 5% to 0.97%, with no change to costs or effectiveness of codling moth control, the costs of the methyl bromide protocol would decrease to 5 cents per pound from 8 cents per pound. This would reduce P_J^D to 108 cents per pound, just equal to P_J . In this case, when removing the fire blight protocol, the cost is not truncated and the full impact of removing the protocol would be felt. Trade would increase to 46,221 metric tons.

If the existing methyl bromide protocol for codling moth were also removed, an unlikely event, Fuji trade would increase by 72,924 metric tons or \$82.7 million.⁶ Removing the fire blight protocol yields only 38% of the trade impact of removing both protocols. In the short run, trade would increase by 33,428 metric tons.

In the 2005/06 season, only a handful of growers participated in the Japanese export program and none exported to Japan. Many growers may have had more pessimistic assessments about the potential damage of methyl bromide or share of apples appropriate for the Japanese market, which could account for the low participation rate. Shippers reported that relative prices during the marketing season did not support exports. This was also the first season under the new protocol so growers may not have had time to adjust fully to new market conditions. After a history of difficult trade, some risk-averse producers may prefer to wait to see how the protocol works out.

Conclusions

The United States and Japan have had a long-standing dispute regarding Japanese phytosanitary requirements for U.S. apple exports. In the wake of the recent decision by the WTO, ruling that Japan's fire blight protocol was in violation of its WTO obligations, Japan agreed to bring its fire blight protocol into compliance. This article focuses on how the change in these phytosanitary requirements may affect the costs of growing apples for the Japanese market and U.S. apple sales to Japan.

This analysis employs a simple participation model to estimate the economic costs of the Japanese phytosanitary barriers. The design of the Japanese program—which forces growers to make decisions about participating in the early spring and bear the expected costs of the program without knowing what benefits will accrue, if any, until the following marketing season—substantially increases the economic costs to the grower. The model yields an estimate of the economic cost of the phytosanitary programs of 15 cents per pound, much higher than the accounting costs of 5 cents per pound. After long-run adjustments, Japanese Fuji apple imports could increase to 27,639 metric tons and \$31.3 million with the elimination of the fire blight protocol. Results are sensitive to model parameters, particularly the degree of damage caused by methyl bromide. The model highlights the continuing role of the codling moth protocol in deterring trade.

There are several important advantages to the participation model. It captures the economic cost, as opposed to the accounting cost, of an export protocol with an uncertain outcome. It also provides an explicit derivation of the cost in terms of the phytosanitary protocols. As a result, analysts can develop economic costs of the separate risky protocols to analyze the case where only some of the protocols are eliminated or when the costly protocols are changed but not eliminated. In addition, this model does not face an upper bound on estimates of the cost of phytosanitary barriers as does the standard price-wedge model. There are also disadvantages to the participation model. It is information intensive. In addition to comparable prices, the model requires detailed information about the protocols. Such information may often be best described as an educated guess. Also, the model can realistically only provide a lower bound of the economic cost since the model assumes risk-neutrality. Like the standard price-wedge model, this model relies on the strong assumption of perfect substitution. Additional research to incorporate imperfect substitution would allow analysis to separate out the impact of potential quality differences and phytosanitary barriers.

The participation model utilized to examine the U.S.–Japanese apple dispute can serve as a guide for estimating the economic cost and trade impacts of other phytosanitary measures. Any phytosanitary protocol that requires growers to commit to *ex ante* expenditures to qualify for an export program—steps that result in higher costs without the assurance of higher economic benefits—or use a practice with uncertain impacts on quality are likely to have more impact on trade than accounting costs alone would indicate. Designing phytosanitary standards that are equivalent in efficacy but present less economic risk to farmers and international traders would facilitate the flow of agricultural products.

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Endnotes

¹To simplify, this model assumes that the decision regarding relative prices at harvest time is accurate. In fact, even after the postharvest treatment relative prices might not be favorable for trade and growers would redirect apples to the domestic market.

²The model assumes Japan is a small country case so U.S. (a proxy for world) prices are not affected by changes in Japanese trade (this introduces an upward bias on the trade impact). We assume that k is invariant with respect to the value of the shipped apples.

³See Yue, Beghin, and Jensen for the literature on Japanese consumer preferences and substitution between Japanese and U.S. apples.

⁴Once the fire blight protocol is removed, results do not vary across h since it only affects the cost of the fire blight protocol. C_{PP} now depends only on P_H , d , and C_{MBO} .

⁵This is an upper bound on potential U.S. gains. Currently, only a few countries have access to the Japanese apple market—the United States, France, New Zealand, Australia, South Korea, and Nepal. Since Australia, South Korea, and Nepal claim to not have fire blight, there should be no change in their export protocols or exports. Even if the other countries renegotiate their fire blight protocols, there may not be much market impact. France and the United States share the same season but the United States is closer to the Japanese market. New Zealand may be able to export more in the summer months.

⁶Yue, Beghin, and Jensen found trade would increase between 5,000 and 174,000 metric tons with the most plausible estimate at the low end of the range. Differences in results depend crucially on various model assumptions, highlighting the difficulties in answering what may, at first glance, seem like a simple question.

Appendix: Additional Model Detail

Expected Net Revenue of Japan Export Program

Expected net revenue for outcome 1: $ahg\{[bdP_E + (1 - b)P_H] - [C + C_{FB} + bC_{MBO}]\}$.

Expected net revenue for outcome 2: $ah(1 - g)\{P_H - [C + C_{FB}]\}$.

Expected net revenue for outcome 3: $a(1 - h)(P_L - (C + C_{FB}))$.

Expected net revenue for outcome 4: $(1 - a)h(P_H - (C + C_{FB}))$.

Expected net revenue for outcome 5: $(1 - a)(1 - h)(P_L - (C + C_{FB}))$.

Summing the net revenue for each outcome gives:

$$R_j = ahgb[dP_E - P_H] + (hP_H + (1 - h)P_L) - [C + C_{FB} + ahgbC_{MBO}].$$

Prices

The model uses fob prices for large (size 72), Washington State Extra Fancy Fuji apples assuming they would compare favorably to the average Japanese Fuji apples. Japanese apple prices represent average Fuji apples at the Tokyo wholesale market. The average of six years of monthly prices, excluding data from July and August when apple markets are very thin, represents expected U.S. and Japanese

Fuji apple prices (Washington Growers Clearing House; Ministry of Agriculture, Food, and Fisheries).

Phytosanitary Protocol Program Parameters

Due to data limitations, the *ex post* parameters deduced from the 1994/95 season based on Red and Golden Delicious apples (the only kinds of apples that could be exported then), not *ex ante* parameters for Fuji apples, must suffice. The share of core acres to core plus buffer acres, b , and the probability of core and buffer acres passing the fire blight inspection, a , are based on the 1994/95 season. The share of Fuji apples expected to meet Japanese consumer standards, h , is based on industry estimates that ranged from 10–20% to 24% (Smith; Archer, 2004). High-quality Fuji apples are relatively tolerant of methyl bromide fumigation compared to Red Delicious varieties (Drake, Moffitt, and Mattheis; Drake and Moffitt; and Archer, 2006). Research on Red Delicious found that after fumigation and storage only 83.8% of fumigated apples were marketable compared to 100% of nonfumigated apples. There is no estimate of the percentage of Fuji apples damaged to the point where they cannot be sold but an estimate of 5% to 10% (equivalent to a 5% to 10% price discount) seems plausible to industry experts.

Economic Costs of the Phytosanitary Protocol

The updated *ex post* accounting costs for the phytosanitary protocols were 5 cents per exported pound of apples (Appendix table). The 1994/95 cost estimate for methyl bromide was adjusted to the current price to account for the recent, rapid price increase, and all other costs were adjusted for inflation. The *ex ante* accounting cost is 3 cents per pound of treated apples, assuming all apples are treated. The *ex ante* accounting cost, C_{FB} , equals 0.15 cents per pound treated (the updated *ex post* accounting cost divided by all expected production—1994/95 core plus buffer acres, all divided by the expected apple yield (an average yield over five years)). With respect to the methyl bromide and other costs, the treatment is only incurred on exported volume so the *ex post* accounting and *ex ante* accounting costs, C_{MBO} , are equal. The *ex ante* economic costs are based on the *ex ante* accounting costs following the formulas in the Appendix table.

Transaction Costs and Tariffs

Transaction costs to move the apples from the Washington growing area to the Tokyo wholesale market are based on industry and government sources. Costs include: shipping costs from the Washington growing area to the port of Seattle; freight and insurance costs to ship apples from Seattle to Japan; the 5% Japanese consumption tax; customs clearance and terminal service charges; warehouse charges and transportation costs from the port to a warehouse; and importer profits (Agricultural Marketing Service; U.S. Embassy in Japan, 2005). In Japan, the tariff of 17% is assessed on the landed value, which includes the cost of insurance and freight to the port in Japan.

Appendix table. Accounting and economic costs of participating in the Japanese apple protocols

Type of cost	Ex post accounting costs per pound of exported apples		Ex ante accounting cost per pound of apples treated		Ex ante economic costs per pound of produced apples	
	Cents	Definition	Cents	Definition	Cents	Definition
Fire blight costs	2		C_{FB}		BC_{FB}	7
Methyl bromide and other postharvest costs	3		C_{MBO}		C_{MBO}	3
Cost of damage from methyl bromide fumigation	n.a.		n.a.		$(A - 1)(P_H + BC_{FB} + C_{MBO})$	5
Total costs	5		$C_{FB} + C_{MBO}$		C_{PP}	15

1. na = not applicable. The ex ante accounting cost of the fire blight protocol is 0.15 cents per pound treated.
Source: Economic Research Service, U.S. Department of Agriculture.

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